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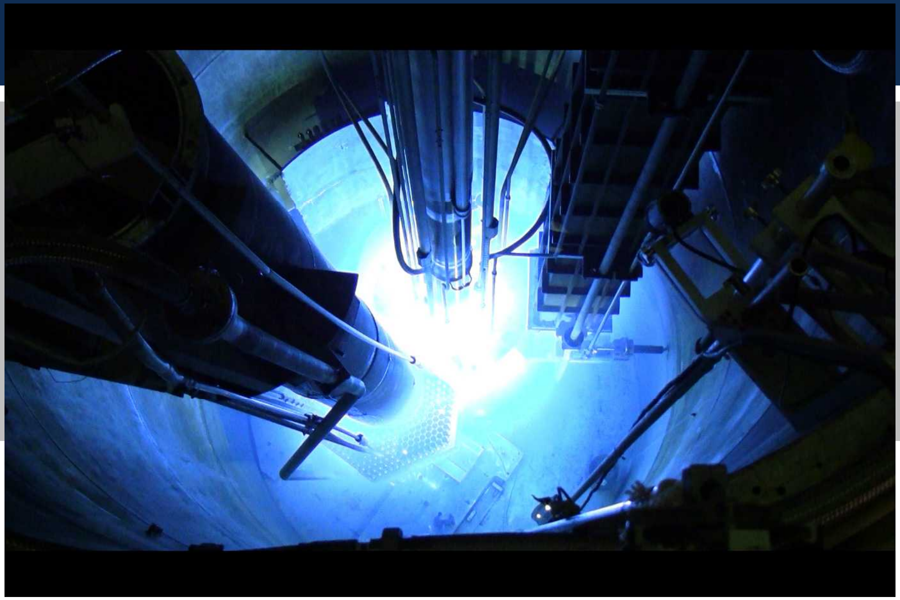 

Annular Core Research Reactor Updates

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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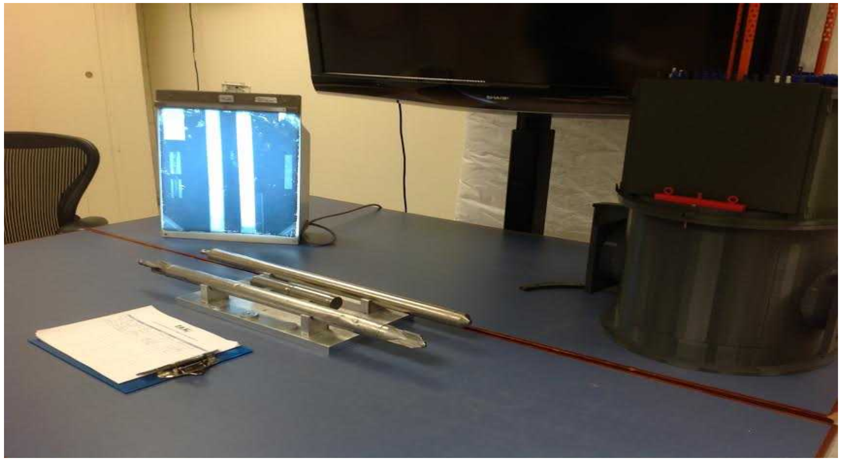
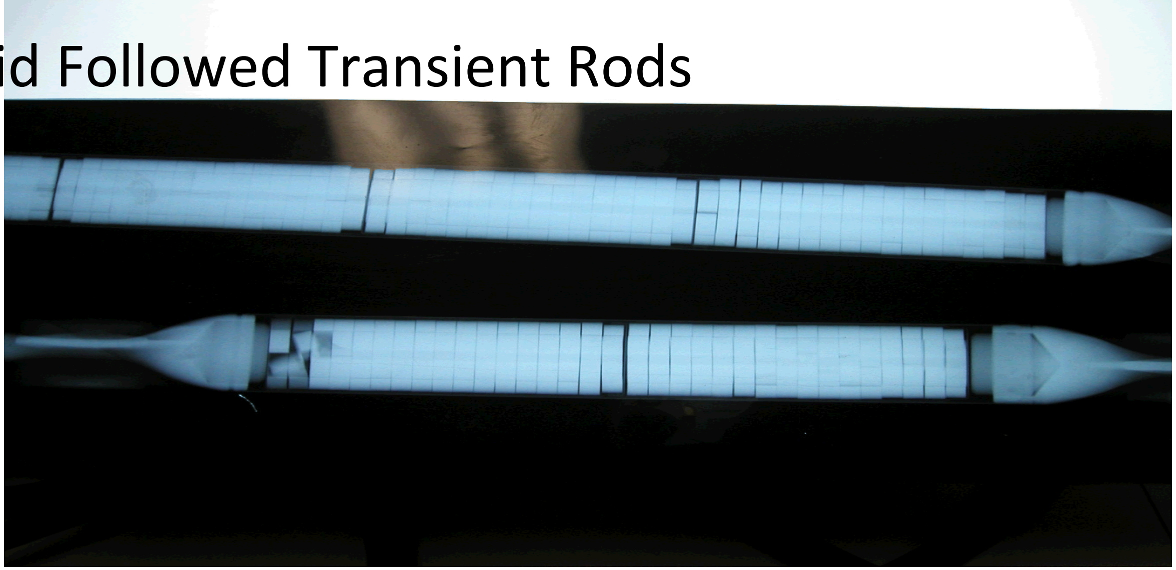
Outline

- Overview of the Annular Core Research Reactor (ACRR)
- Neutron Radiography Tube Characterization
- Fuel Ringed External Cavity II (FREC II)
- I&C accomplishments and lessons learned
- Rod Control issues and fixes
- Upcoming projects and upgrades to the facility

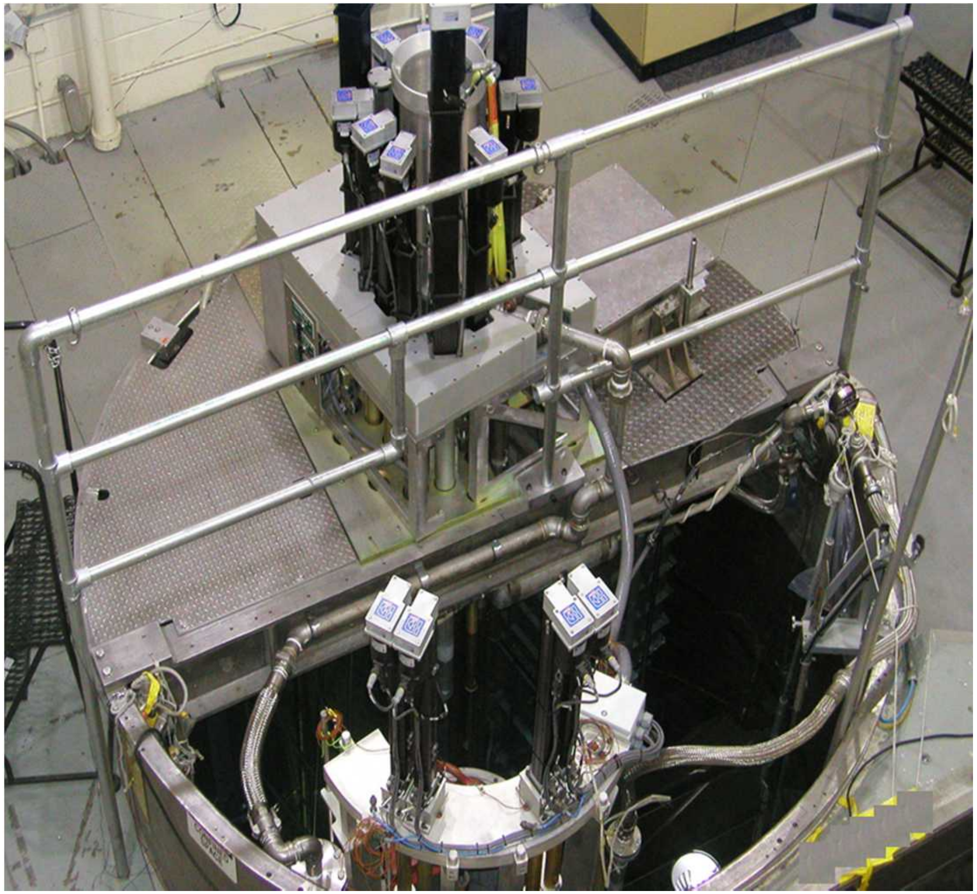


What is the ACRR?

- Pool-type research reactor at Sandia National Laboratories located in Albuquerque, New Mexico
- 50,000 MW in pulse mode and 4 MW in steady state mode
- BeO-UO_2 ceramic fuel can safely run up to 1,400^oC (2552 ^oF)
- 236 fuel elements including 2 fuel followed safety rods, 6 fuel followed control rods
- 3 Void Followed Transient Rods



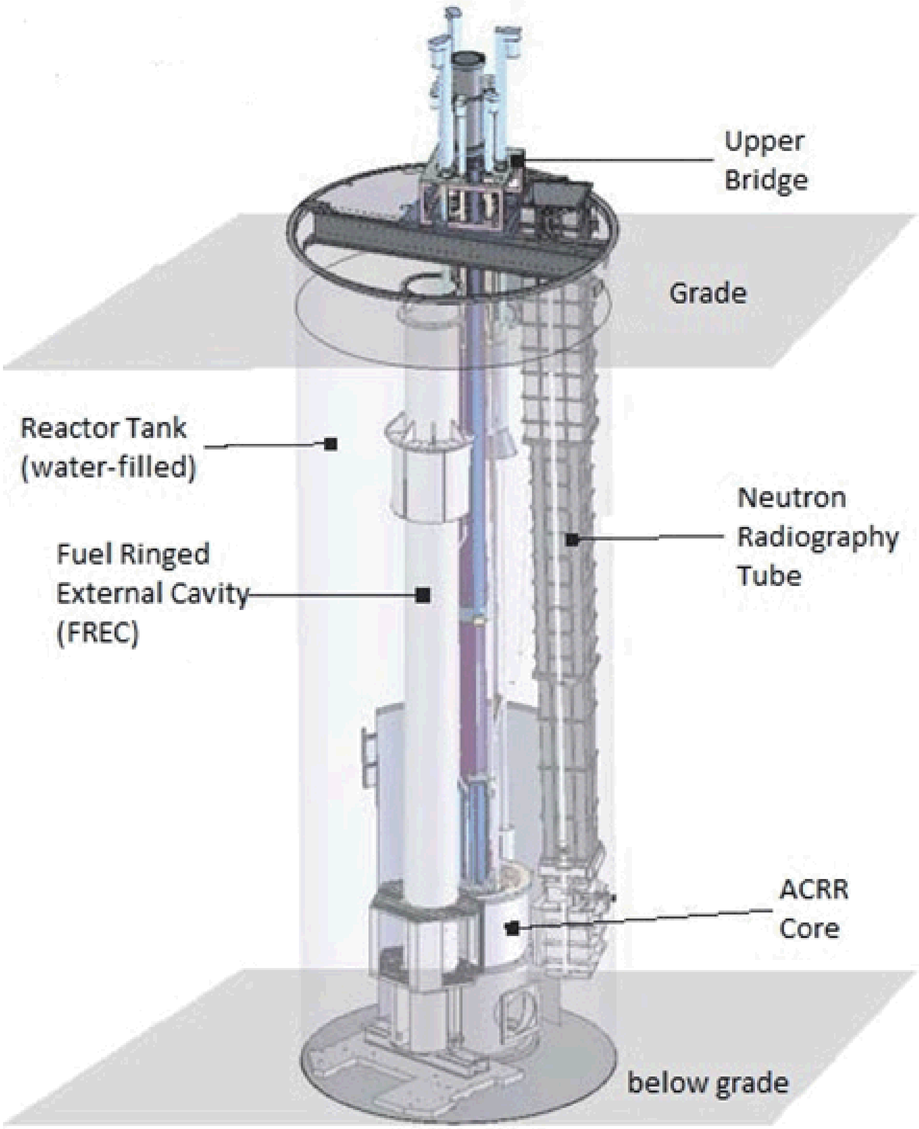
Purpose of the ACRR



- ACRR's mission is neutron vulnerability & hardness testing as well as certification of weapon systems & components.
- ACRR provides experimental data for the development and validation of radiation effects simulation models on electronic systems.
- Conducts basic radiation effects material studies.

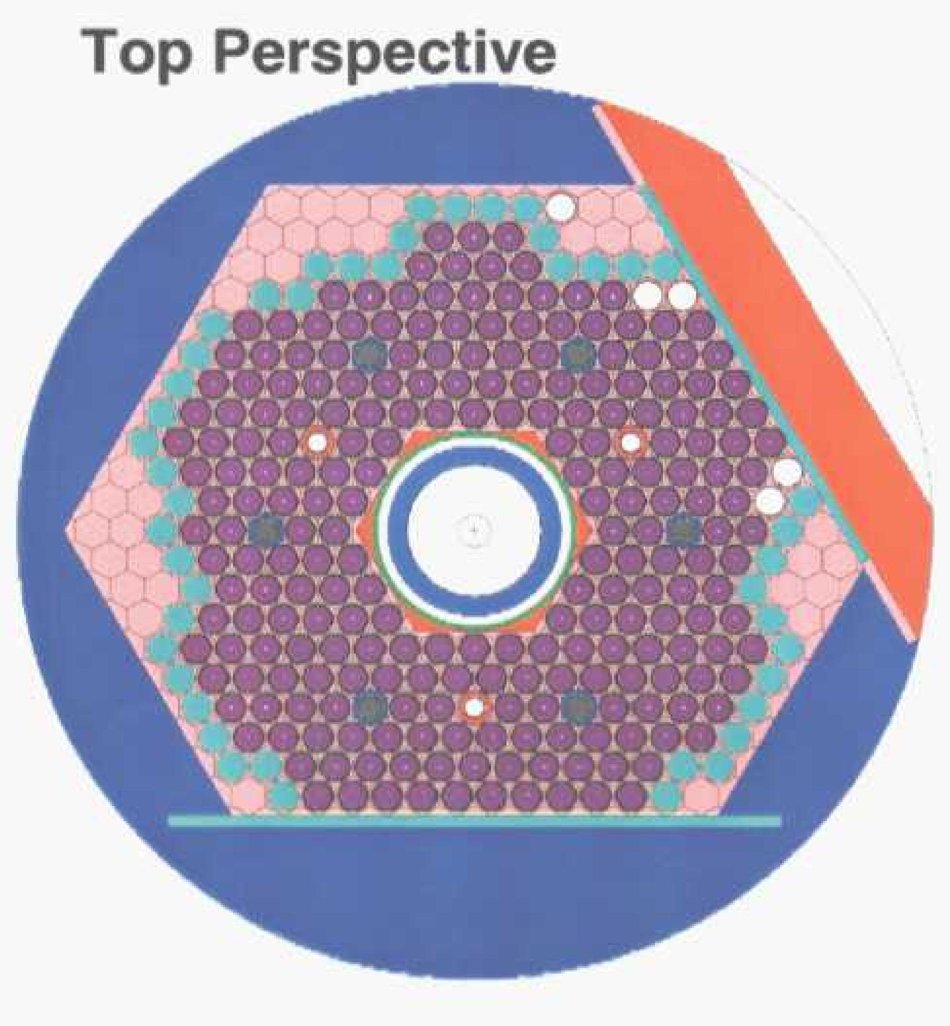
Experimentation Facilities

- Central Cavity
- FREC-II
- Neutron Radiography Tube
- In core testing
- Staff includes 3 reactor supervisors and 5 reactor operators. Responsible for operating the reactor, engineering, trair maintenance, procedures, housekeepin; (Everything)



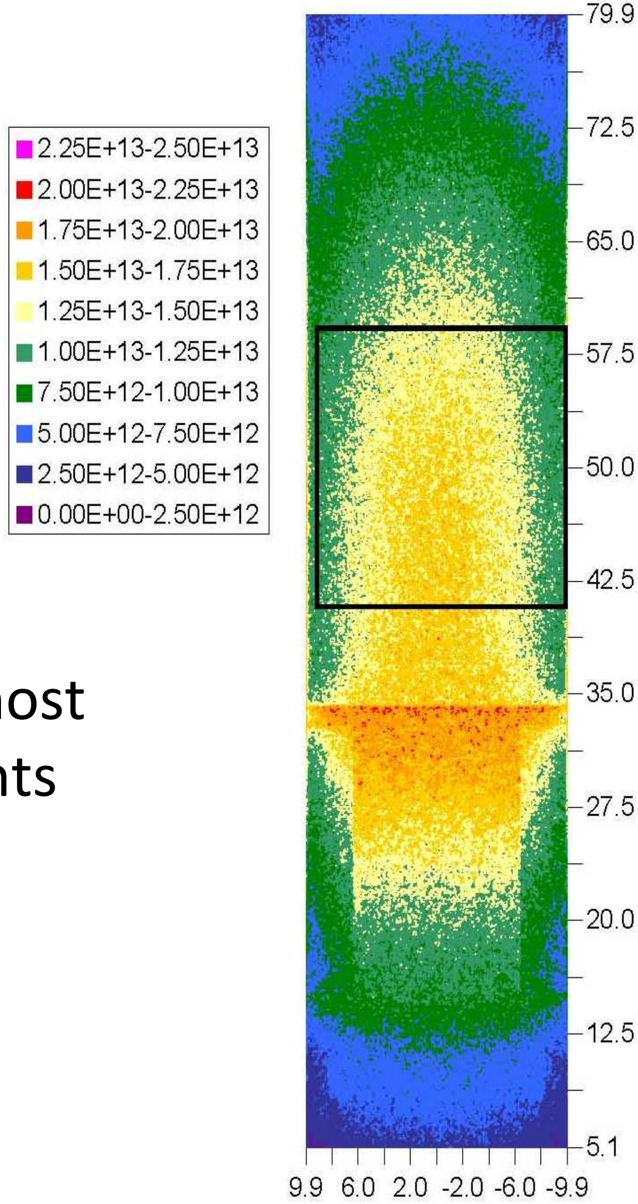
ACRR – Current State

- The core is formed by fuel elements with their vertical longitudinal axes arranged in a hexagonal grid around a dry irradiation cavity.
- External cavities are installed as needed on the side of the reactor where a flat area on the upper grid plate allows close coupling to the core.
- The dry cavity (9 in) diameter extends the full length of the pool extending through the core



ACRR Central Cavity

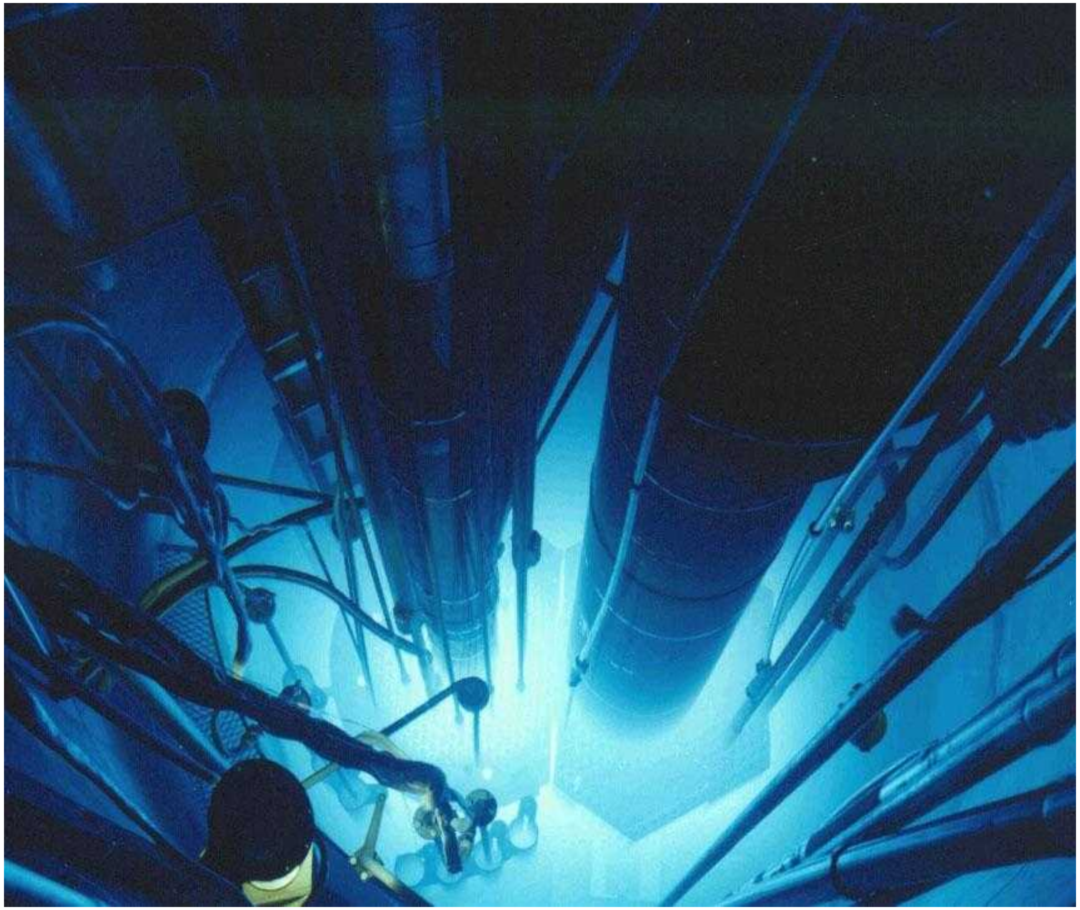
- ACRR conducts over 300 operations/year
- Central cavity neutron flux is
  4E13 n/cm^2-s at 2 MW
  [56% > 10 keV, 45% > 100 keV]
- Uniform fluence across regions of central cavity.
- 9 inch diameter can accommodate most electronic parts and many components for experimenter purposes



n flux in the annular core (n/cm^2/MJ)

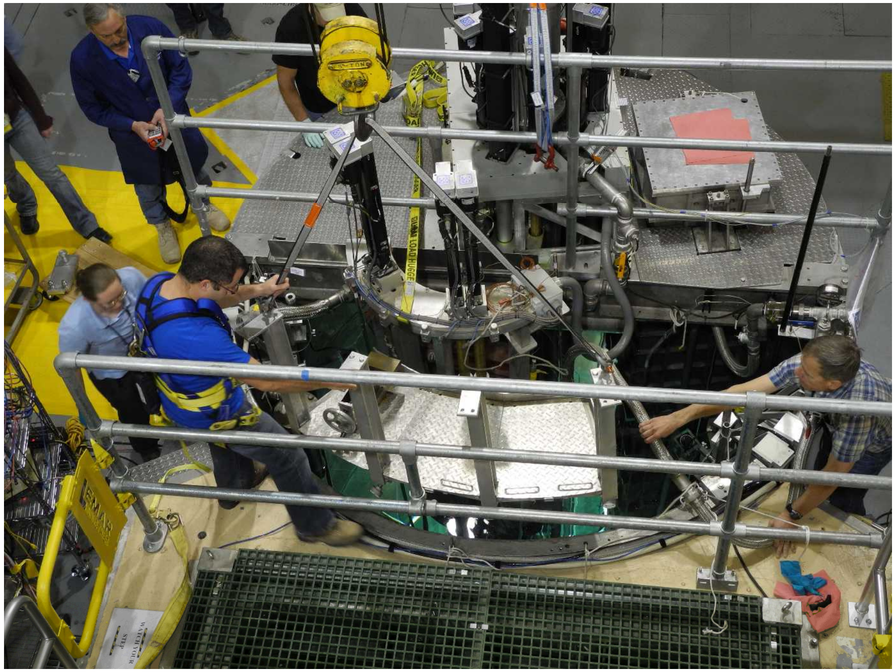
FREC-II Experiment Facility

- 22 inch cavity with flux gradient
- 188 TRIGA fuel elements with void chambers installed
- Not a critical assembly by itself, needs to be coupled to ACRR
- Used for larger sized experiments unable to fit in ACRR central cavity



Coupling FREC-II

- FREC-II had not been coupled in approximately 10 years
- Procedures were not clear to new operators, rigging inspections had lapsed, rod control upgrades not tested on FREC-II rods, new hardware in reactor tank in the way



Shield Plug Removed

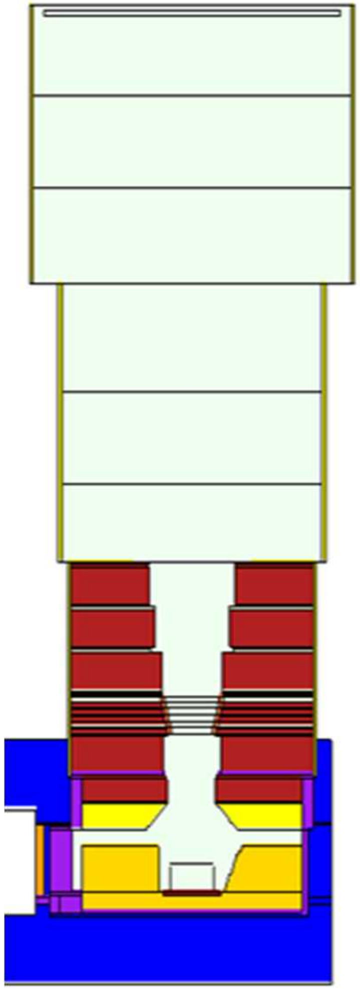
Underwater Camera

Neutron Radiography Tube

- The Neutron Radiography Facility provides a thermal neutron beam in a large cavity used for neutron imaging, has not been used since the addition of 6 new reactor operators.
- The ACRR neutron radiography system has four apertures (65:1, 125:1, 250:1, and 500:1) available to experimenters.
- The neutron flux rate and spectrum as well as the gamma dose rate were characterized at the imaging plane for the ACRR's neutron radiography system for the apertures

Models

- Solid Works (left) MCNP (right)
- MCNP was used to model the neutron radiography tube to provide an estimated neutron energy spectrum, neutron flux, and gamma energy spectrum at the imaging plane.
- Dosimetry foils and detectors were used to benchmark the MCNP model.



Maximum Size Pulse

I&C Hardware & Software Upgrade

- Computer and network systems running software and hardware for reactor control were about 8 years old.
- Watchdog monitor used to verify systems all communicating properly was causing spurious shutdowns which interfered with operations
- Major overhaul of network and PCs resulted in eliminating the spurious shutdowns and provided staff, experimenters, and oversight with assurance that the reactor could continue to operate.

Complexities and Challenges

- First course of action – replace network switch
  - When replaced, the frequency of the spurious shutdowns increased dramatically. The old switch was reinstalled. The network reliability was monitored by technicians at SNL and there was no indication of any issues using their tools.
- Second step – Replace ethernet cables connecting the 14 PCs and components to one another. Cat5 to Cat6a shielded
  - This step eliminated the watchdog shutdowns completely. The new network switch was installed and successfully runs with no spurious shutdowns a year later.
- Third step – Adding second layer of network protection
  - It was discovered during testing of new network hardware that if all computers simultaneously stopped communicating that a shutdown did not occur automatically in a timely manner.
  - Solution – add network monitoring into runtime software on fieldpoint hardware to cause shutdowns if network coms are lost

Final step – Replacement of PCs

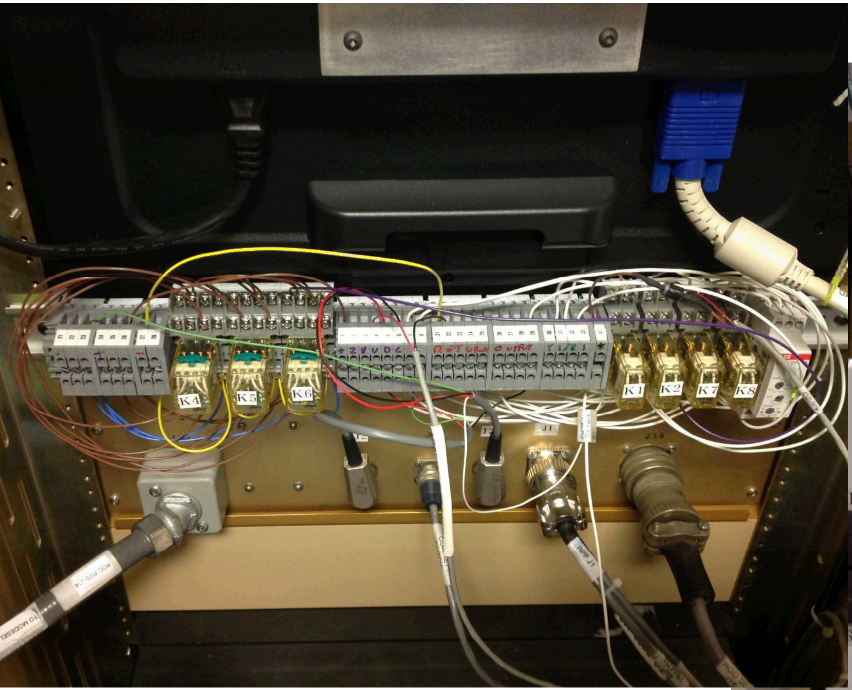
- Replacement with new hardware, solid state drive upgrades, monitors.
  - Hardware was difficult to find that supported rod control system integrated hardware and current processors, ram, power supplies, etc.
  - Assembly of computers required some modifications to the cases to allow the programmable multi axis controllers used for rod movement to fit and connect to a PCI slot.
- Upgrading software – not plug and play ☹
  - Upgraded Windows XP to Windows 7 (Corporate requirement), LabView2002 to 2012, PMAC software, Microsoft Office.
  - Required new programming for LabView code to work with PMAC software and timing cards. Software changes needed to be transparent to operator for procedure compliance and best ConOps practices.

Before and After

Rod Control Issues

- Several occurrences of individual rods moving without commands
- One occurrence of control rod bank drives moving outward when commanded in
- Thought to be due to buffer overflows in the computing system for the rod controller
- Major code revision to prevent any more uncommanded rod motion
- Installed temporary modification to prevent rod motion if an error in motion logic is seen. Planning to remove after verification of new program is documented.

Enable Relay

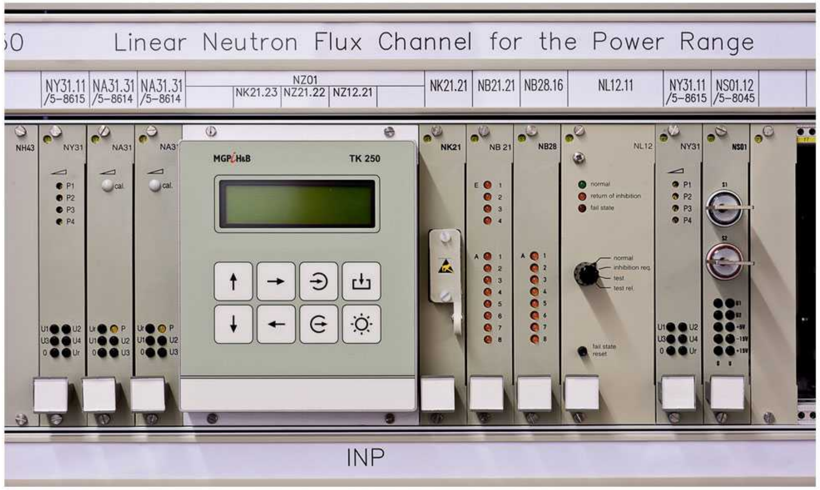


Enable Relay Explained

- Controls rod drive power through LabView Fieldpoint and RO enable circuit.
- The operator must be issuing a command and the drive feedback must be responding to the command
- If not, an error occurs and drive motion is stopped by opening the relays controlling drive motion
- Once the error is reset normal drive motion can occur assuming there are no faults
- Monitors current and voltage to drives for troubleshooting

Later this year

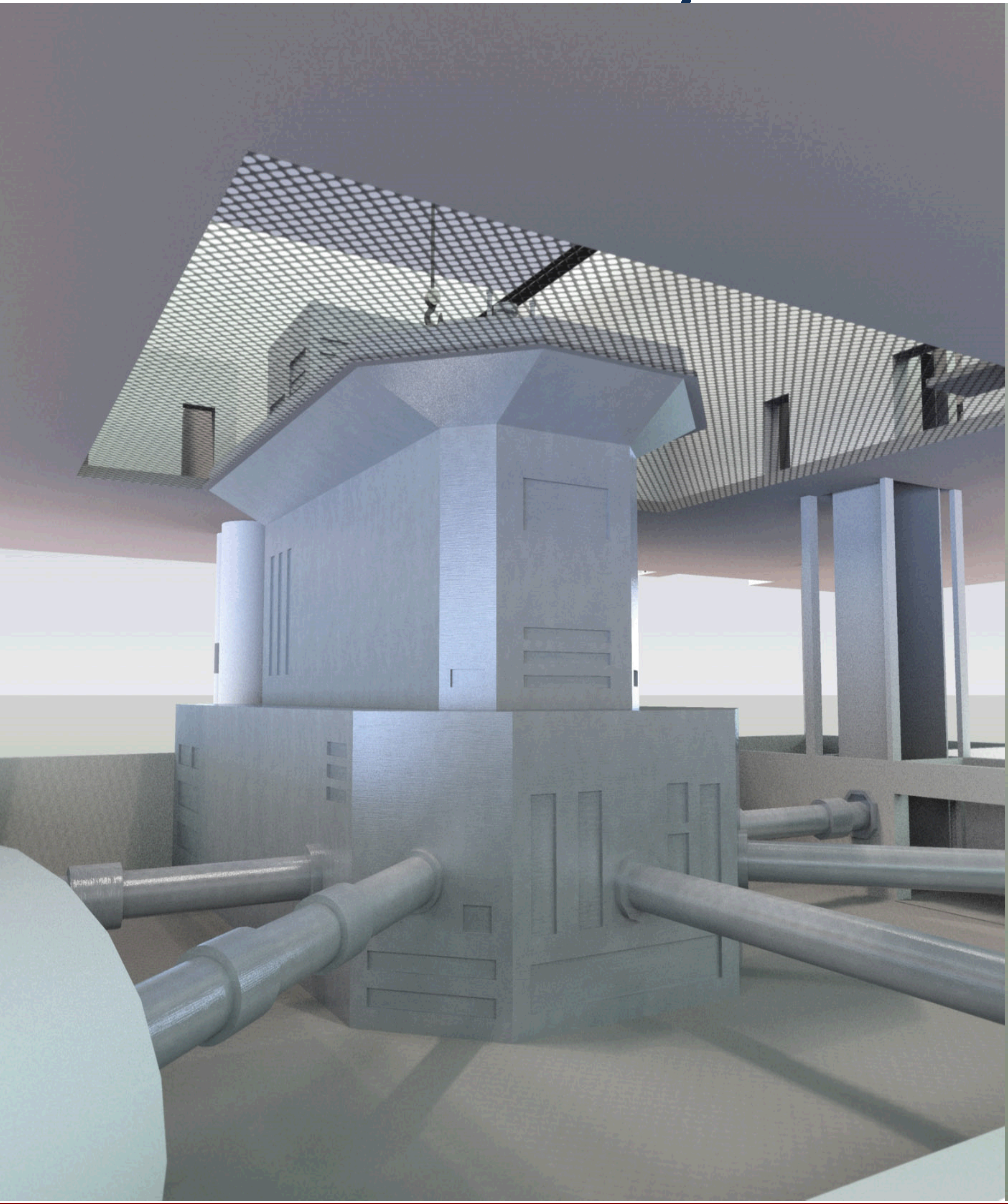
- New neutron flux monitoring equipment from mirion DWK250
  - Easier to calibrate and more user friendly
  - Current flux monitoring has noise induced dropouts for linear scale

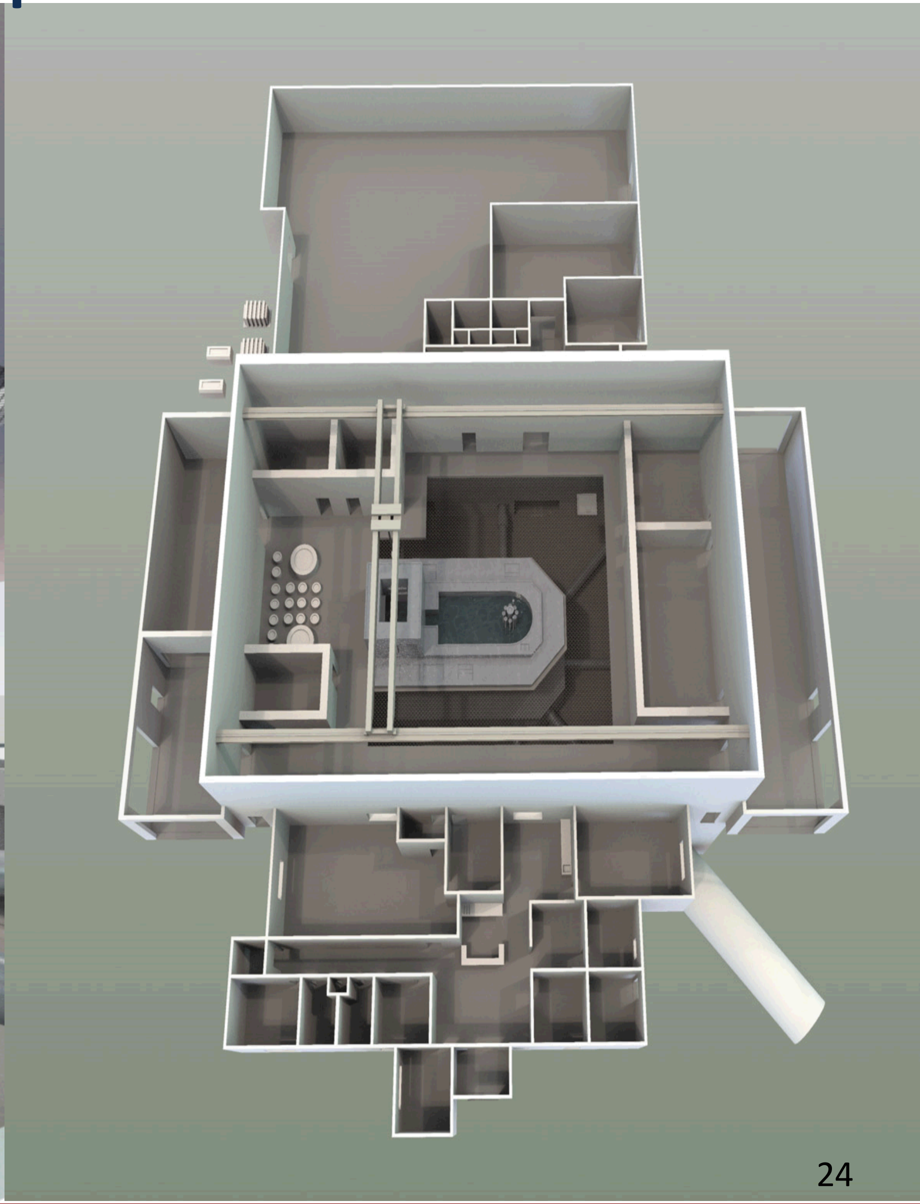


Next year

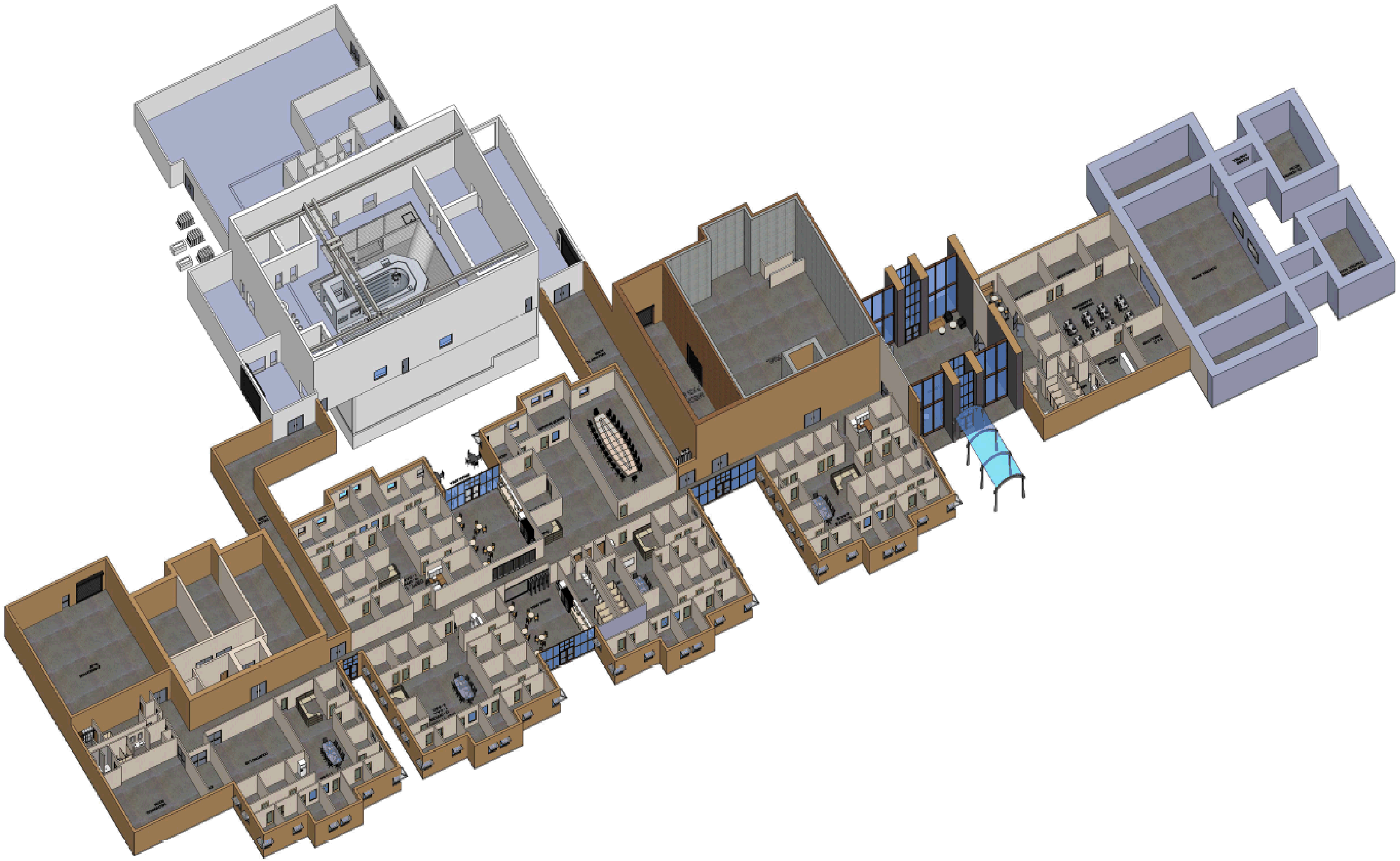
- Reactivity control system upgrade
  - Replacing rod control system
  - Replacing remote I&C monitoring systems
  - Replacing console computers with industrial rated PCs
- Working with Merrick (Local project management) and Hurst (technical aspect of project)

Futures Study Conceptualization





Futures Study Conceptualization



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